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TRACTOR EXPERIENCE IN ILLINOIS

A STUDY OF THE FARM TRACTOR UNDER CORN-BELT CONDITIONS

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THE GAS TRACTOR as a farm machine has already proved very valuable under many conditions, though it is still in process of development, and types change from year to year. As the tractor has not yet assumed a fixed place in general farm practice, the prospective purchaser may have difficulty in determining whether his conditions justify the expenditure, and if so what size of machine he should buy. The experience of more than 600 Illinois tractor owners, set forth in this bulletin, should help the corn-belt farmer in obtaining answers to his questions regarding advantages and disadvantages of the tractor, size of machine required, original cost, cost of operating, length of life, kind, quantity, and quality of work performed, and other vital questions.

TRACTOR EXPERIENCE IN ILLINOIS.

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CONSTANTLY increasing numbers of inquiries regarding the value of the gas tractor for farm work are received by the Department of Agriculture from farmers in all parts of the country. To meet this demand for information the Office of Farm Management has obtained thousands of detailed reports from tractor owners in all sections of the country, showing just what is being accomplished by these outfits in actual service on farms. Farmers' Bulletin 719, "An Economic Study of the Farm Tractor in the Corn Belt," was based on reports obtained early in 1916 from more than 200 tractor owners in the State of Illinois, but it is deemed expedient now to present what is essentially a revision of that bulletin, based on detailed reports received from 359 tractor owners in Illinois during the summer of 1917, and from 284 in the spring of 1918, thus bringing the information more nearly up to date. The aim is to present what are considered to be, from the farmer's standpoint, the more important facts and figures brought out in the reports of experienced tractor users.

Though the figures contained herein apply to conditions as they existed in Illinois in the summer and fall of 1917, in general they should be applicable, not only in Illinois, but throughout the corn belt, since the farms from which the reports used in this bulletin were received are typical in most respects of corn-belt conditions.

It should be understood clearly that these figures represent average results obtained in actual service and not the maximum possibilities of the tractor. These averages are believed to be worth more to a farmer in determining the possible value of a tractor for his work

than are maximum figures from tests, no matter how carefully conducted. The latter would represent, at best, only a limited number of machines operated under especially favorable conditions, while the averages here given represent a large number of machines operated by incompetent as well as by competent operators, and under actual service conditions which it is exceedingly difficult to duplicate in tests. A prospective purchaser may reasonably count upon equaling the average performance of his neighbors. He should strive, of course, to equal the maximum performance of experts, but should not depend upon being able to accomplish such results in order to justify investing in a tractor. For example, an outfit with sharp, new plows, operated by an expert, may plow an acre of ground with, say, 1 gallon of gasoline, but since, under ordinary conditions, with plows that have been sharpened several times and perhaps are not in perfect adjustment, the fuel consumption will ordinarily equal at least the average given herein ($2\frac{1}{2}$ gallons), it is obvious that the farmer should use the average figure in determining the possible value of the tractor for this work, rather than the exceptional figure.

This bulletin is not intended to influence the farmer either for or against the tractor as a source of power, but only to assist him in determining whether his individual conditions justify the use of such power. The question whether a tractor will prove profitable on a particular farm is a problem in farm management which must be worked out for that individual farm. Judging by the reports of owners, however, it will prove profitable on most corn-belt farms of 180 acres or over, while in the opinion of these men it should not be expected to do so on farms of much less than 130 acres. It is believed that consideration of the various influencing factors mentioned in the following pages will be of material assistance to farmers in deciding whether a tractor will prove a wise investment on their own farms.

CORN-BELT CONDITIONS.

Corn is the principal crop grown on practically all these farms, approximately 40 per cent of the entire acreage being planted to this crop. Oats are raised in most cases, the acreage averaging about one-half as great as for corn. The next crop in point of acreage is wheat, which is raised to a limited extent on more than half of the farms. Hay, including alfalfa and clover, forms a large percentage of the remaining crops. Both spring and fall plowing are practiced, slightly more ground being plowed in summer and fall than in the spring. The land is mostly level or gently rolling, in general quite free from stone, and while there is a good deal of rather heavy loam, the plowing conditions are not severe, except when the ground is very dry. The fields are generally regular in shape and range in size from about 20 acres up.

The above-mentioned facts relative to the general characteristics of the type of farming followed should be kept in mind when considering the figures furnished by tractor owners in this section.

DATA FOR 1917-18 COMPARED WITH 1916 DATA.

Probably the most significant difference between the reports received from the tractor owners in 1917-18 and those received in 1916 is the much larger percentage of men who reported that the tractor had proved a profitable investment. In 1916 less than 80 per cent reported that the tractor had proved a profitable investment, whereas in 1917 and 1918, 90 per cent, or 9 out of 10 men, made such reports. This is partly due to the improvements which have been made in the tractor, and partly, of course, to the increased prices commanded by both farm products and farm labor during the past year. In this connection, however, it should also be noted that while in the beginning of 1916 a considerable number of the large old-model tractors commonly used five or six years ago were still in use, by the end of 1917 practically all of these machines had been discarded, and the reports on which this bulletin are based deal almost without exception with the small or medium-sized tractors which have been developed during the last three or four years, and which not only cost less in the first place, but give every indication of having a longer life and lower repair charges than the older models.

Another significant difference between 1918 and 1916 is the increase in the percentage of 3-plow outfits and the decrease in the percentage of 2-plow outfits in use, which is in keeping with the opinions of tractor owners set forth in Farmers' Bulletin 719, to the effect that the 2-plow outfit is not large enough for the average corn-belt farm, and that the 3-plow or 4-plow machines are better adapted to the conditions in this section.¹

Nearly three-fourths (71 per cent) of all the tractors in Illinois of which reports were received in 1917-18 were pulling 3 plows, while more than three times as many 2-plow as 4-plow machines were in use. The recommendations of the owners of these machines as to the best size of tractor for their particular farms show that only 11 per cent recommend 2-plow machines, while 13 per cent advocate the use of 4 plows, and the remaining 76 per cent, or more than three out of four men, advise the 3-plow size.

¹ In all cases the size of tractor is referred to by the number of 14-inch plows pulled rather than by the horsepower ratings. This is done because manufacturers do not use a uniform method of rating their outfits, and a comparison of different tractors by their horsepower ratings is practically valueless. It is believed that grouping by the number of plows pulled, under conditions which are not only fairly uniform but which represent average conditions, offers a more reliable comparison than would be obtained by grouping according to the horsepower ratings.

ADVANTAGES AND DISADVANTAGES OF THE TRACTOR.

The theoretical advantages of mechanical power for farm work are obvious, but to the prospective purchaser of a tractor the important thing is to know what the men who have used tractors have found to be their principal advantages and disadvantages in actual practice.

Several hundred Illinois tractor owners were asked the questions: "What do you find to be the principal advantages of a tractor for farm work?" and "What are the principal disadvantages?" In the replies to these questions the same points are emphasized as were mentioned in Farmers' Bulletin 719.

The ability of a tractor to do heavy work and do it quickly, thus covering the desired acreage within the proper season, is considered the principal advantage. The saving of man labor and the doing away with hired help, enabling a man to farm a larger acreage and thus increase the crops he can raise, is next in importance. The ability to plow to a good depth, especially in hot weather, is also emphasized, while other points are mentioned occasionally, but not in a sufficient number of cases to warrant listing in this connection.

The availability of the tractor for work at night as well as by day was not mentioned by many owners, although theoretically this should be a decided advantage.

Under disadvantages, the difficulty of efficient operation is the principal point, and this fact should be kept in mind by everyone who considers the purchase of a tractor. (See "Operation," p. 24.) Packing of the ground when damp is mentioned by several owners, but not as frequently as was the case when more of the older and heavier machines were in use. Expensiveness, delays, and inability to use the tractor for many kinds of work for which horses could be used are disadvantages mentioned by several owners. Other disadvantages are noted, but not by a sufficient number to warrant mentioning here. It may also be noted that disadvantages are not emphasized to so great an extent as formerly, nor in nearly so many cases as advantages.

SIZE OF FARM AND TRACTOR.

Though the introduction of an improved farm machine may be expected to reduce the man labor required for farm operations, thus permitting one man to accomplish more work and so farm more land than with the older methods, it is obvious that a farm business must be of sufficient size to permit the economical use of an improved machine in order to justify the necessary investment. That is, many small farms must either use the old methods or hire a modern outfit, because the small amount of work to be done each year does not warrant owning the machine.

Among the more important facts disclosed by a study of the use of the tractor for farm work are those relating to the increase in the acreage which can be farmed by one man when a tractor is used in connection with horses, over that farmed with horses alone. Approximately one-third of all the Illinois farmers reporting increased the acreage they were farming after purchasing a machine, the percentage of men so doing being slightly higher in the group reporting the tractor profitable. The percentage of the entire number of tractor owners who have enlarged their farms is significant, for whereas there has been a tendency for the size of corn-belt farms to increase in recent years,¹ the increase among farms in general is not nearly so pronounced as in the case of farms on which tractors are used.

Farm-management studies repeatedly have demonstrated the fact that a great many farms are not large enough to furnish economical employment for the equipment which they possess. That is, the various implements are capable of doing the work on a larger acreage within the time which the seasons allow, and the purchase or renting of additional land often will increase the gross receipts considerably without materially increasing the operating expenses. This increase in the size of farms upon which tractors are used is merely another proof of the fact that the use of improved farm implements increases the amount of land one man will farm.

With the tractor, as with any other farm machine, it is important that a suitable size should be selected for a given acreage. A few years ago there was a wide range in the sizes of tractors on the market (outfits pulling from 2 to 14 plow bottoms being sold), but there has been a decided tendency during the last year or two to reduce materially this wide range in size, and by far the largest percentage of the tractors sold at this time pull either 2, 3, or 4 plows, with the 3-plow size much the most numerous. For several reasons the large outfits did not prove successful or economical under ordinary farm conditions, and for a short time the tendency was strong to go to the other extreme, most of the tractors produced and sold for a short period being 2-plow machines. However, during the last two years, and especially during the 1917-18 season, the tendency has been toward a somewhat larger tractor, with the result that three-fourths of all machines studied in Illinois in 1917-18 were 3-plow or 4-plow outfits, with the 3-plow size predominating.

It is doubtless as a result of the more general use of the 3-plow and 4-plow machines, and hence a better acquaintance on the part of farmers with these sizes, that 76 per cent of all owners reporting recommend the 3-plow machines, while 13 per cent favor the 4-plow

¹ U. S. Census, 1910, Vol. V, p. 276.

outfit, and only 11 per cent advise a 2-plow rig, whereas, at the time the data on which Farmers' Bulletin 719 was based were collected (1916), a somewhat greater percentage of tractor owners recommended the 4-plow than the 3-plow outfit, with 13 per cent advising the 2-plow rig. At present there seems to be no doubt that the 3-plow size is the general favorite for corn-belt conditions, whereas the 4-plow is more generally preferred than the 2-plow size.

Even on farms of comparatively small size the 3-plow tractor is recommended by the largest percentage of owners. This, taken with the other facts, seems to indicate that the 2-plow tractor does not increase sufficiently the amount of work which one man can do, hence does not possess, except to a slight degree, the greatest advantage of tractors in general, namely, timeliness in performing farm operations through much more rapid work than is possible with horses. Moreover, a 2-plow tractor does not ordinarily develop enough power to make it suitable for operating grain separators, ensilage cutters, etc., which are tasks for which power is required on the average corn-belt farm. It happens not infrequently that the owner of a 2-plow tractor has to hire an engine with slightly more power to do his belt work, so it is not to be wondered at that in case he were buying another machine he would select one with more power.

The question as to the smallest size of farm on which a tractor may be expected to prove profitable is one often asked and one that has been much discussed. Certainly no more reliable opinion on this point could be obtained than the average of the estimates of a large number of tractor owners. In the opinion of these men the minimum number of acres on which 2-, 3-, or 4-plow outfits may be expected to prove profitable are 130, 170, and 210 acres, respectively.

Attention is called especially to the fact that these figures represent the *smallest* size of farm for which these tractors should be purchased, in the opinion of men who have had experience with them, and not the size on which they can be used most profitably. A farmer who is contemplating the purchase of a tractor and whose farm is smaller than the acreages above given should consider carefully before acting contrary to the opinions of experienced men.

While a tractor is less efficient on a small farm, because of the smaller fields and a correspondingly greater loss of time in turning, larger percentage of the area of fields to be finished up with horses when plowing, etc., these points are not so important as the fact that the small farm is usually thrown out of balance, from an economic standpoint, by the investment of a disproportionate amount of capital in power which can be used fewer days than would be the case with the same machine on a larger farm. The overhead charges per unit of work done are, therefore, much higher on the small farm. The obvious course for the small farmer who has already invested in a

tractor is to acquire more land in order to utilize the tractor more efficiently, which, as mentioned elsewhere, is the course followed by a large percentage of tractor purchasers.

The average sizes of the farms reporting on which 2-, 3-, or 4-plow tractors are in actual use are considerably above the minimum figures given above, being 180, 250, and 300 acres, respectively.

To obtain the fullest degree of satisfaction it is necessary that the proper size of tractor be bought. A tractor which is not powerful enough for the work required of it will prove more or less unsatisfactory, of course, and to exchange it for a larger one entails an expense which would be unnecessary if the right size were obtained in the first place. On the other hand, an outfit which is much too large may be too clumsy or expensive in operation to make it economical for a great deal of work on which a tractor of the proper size could be used with satisfaction and economy.

The 3-plow and 4-plow sizes seem to meet best the tractor requirements of the average farm in Illinois; they enable plowing to be performed much more rapidly than is usual when horses are employed. The man labor is also reduced when using these sizes of tractors, as one man attends to 3 or 4 plows at one time, instead of only 2, as is ordinarily the case where horses are used. (Where modern self-lifting gang plows are used, one man ordinarily handles the entire outfit in plowing, no matter what size gang is used.) Furthermore, the 4-plow size of tractor is generally powerful enough to operate practically all of the machines which are commonly found on the average farm, including the ensilage cutter and the medium-sized grain separator. At the same time it is not so expensive in operation as to prohibit its use for many odd jobs which do not demand a great deal of power.

In purchasing an outfit care should be exercised to obtain one with ample power for the heaviest work which will be required of it. This may be either field work or belt work; probably it will be the latter more often than the former. Frequently the work of a tractor in driving a grain separator or ensilage cutter requires more power than the plowing, and in such cases the tractor bought should be powerful enough to handle the belt work properly. On the other hand, if the belt work which will be required of the tractor will not demand a great deal of power, while there may be a considerable amount of plowing which it will be desired to complete within a limited season, the tractor should be capable of pulling enough plows to enable the work to be performed within the time available.

Then there are cases where only a small amount of belt work is required, and most of the field work will be done with horses, the tractor being wanted merely to make extra power available in rush seasons, or to relieve the horses during hot spells. In such cases the

small 2-plow outfits frequently have proved most satisfactory. Such an outfit has the advantage of not necessitating a large investment and on this account is frequently recommended by experienced men as a good size to buy at first in order to gain experience in the use and care of tractors.

If it is desired to use the tractor for custom work on neighboring farms or for road work, care should be exercised to choose an outfit with sufficient power to handle such work satisfactorily.

As a general rule it is better to err through buying an outfit with too much power rather than too little, but this should not be interpreted as recommending the purchase of the largest sizes. It refers rather to the apparently too-common practice of getting a 2-plow outfit to do work which should properly be done with a 3-plow or 4-plow machine.

COST OF TRACTOR OUTFIT.

While the cost of a tractor should not be the only consideration, it is one of the first points which a farmer must consider. The prices of the various makes of outfits vary considerably for machines of practically the same capacity, owing to difference in quality, sales systems, efficiency in manufacture, quantity produced, etc. It is a grave mistake to sacrifice quality for a saving in the first cost, since there is no other farm machine in which reliability and serviceability count for more than in the tractor. On the other hand, it is poor management for a farmer to invest too large a part of his capital in power. The desirability of further standardization and quantity production of tractors, in order to reduce the first cost, is obvious.

The price which a farmer can afford to pay for a tractor for use on his farm depends upon a number of factors, such as the amount and value of the work which the machine will perform annually, the value of the horses which it will displace, the value of the man labor saved, and the amount of increased returns which reasonably may be expected from its use.

The prices for both tractors and the implements for use with them have been considerably increased during the last two years, owing to the advances in costs of both labor and materials required to produce them. The prices paid for the three sizes most commonly bought during 1917 on the Illinois farms reporting averaged about \$800 for the 2-plow, \$1,100 for the 3-plow, and \$1,400 for the 4-plow machine, while the prices for the plows for use with them averaged about \$115, \$165, and \$235, respectively. In all cases the prices, of course, varied considerably according to the make and quality of the machines. At the beginning of 1918 there was a further general and substantial increase in prices.

LIFE OF THE TRACTOR.

The amount of service which a tractor will perform before it must be replaced is obviously an important factor in determining its value for farm work.

Gas tractors have been on the market for such a comparatively short time, and have undergone so many changes in their process of development, that it is impossible to obtain any really definite figures as to the amount of work a tractor of modern design reasonably may be expected to do before it must be replaced. There are several factors which have considerable influence on the amount of service rendered by a given machine, by far the most important of which is the care it receives at the hands of the operator. (See "Operation," p. 24.) The quality of the outfit, the kinds of work for which it is used, and the conditions under which it is operated will all materially affect its life.

Nearly all tractors are used under conditions which are extremely severe for any kind of machine. They travel over rough and uneven ground, and are subjected to severe shocks both from obstructions in the path and from the load being pulled. A still more injurious condition is their exposure to an almost constant shower of dust and dirt, which, if the soil contains much gritty substance, attacks all gears and bearing surfaces, not only those on the exterior of the machine but also those inside the engine itself, unless an efficient filter is provided for the air intake to the carburetor. This excessive wear due to dust was a very serious matter with the earlier models of tractors, but many manufacturers have made great progress during the last year or two in protecting their machines in this respect.

It is obviously impossible to determine definitely the probable life of the latest model tractors, since none of them are worn out, but the nearest approximation to the actual figure would unquestionably be the average of the estimates given by a large number of men who had used them for a season or two, and who should be in a position to give a fairly reliable opinion as to the additional service that reasonably may be expected from their machines. Tractor owners were asked for an opinion as to the number of years their own particular machines would give satisfactory service, and also to give an estimate of the average life of farm tractors. The replies to these questions showed a tendency on the part of men who reported the tractor as having been profitable to estimate that their own machines would last somewhat longer than the average machine. On the other hand, men reporting them unprofitable usually gave the probable life of their machines as less than their estimate of the average life of tractors in general. The answers to both questions, however,

averaged very nearly the same, being eight and seven and one-half years, respectively.

Of course, these averages can not be regarded as being absolutely accurate, but certainly they should be as nearly accurate as any figures which could be obtained in any other manner at the present time. As a matter of fact there would probably be a tendency on the part of tractor owners to overestimate somewhat. (See "Repairs," p. 13.) It is not believed, however, that a prospective purchaser of a tractor should expect for his outfit a longer life than seven and one-half seasons, and he would be on the safe side if he counted on a somewhat shorter period of service when calculating the probable value of a tractor for his work.

DAYS USED ANNUALLY.

It is obvious that the life of a tractor can not be expressed definitely in terms of years, since the number of years it will last will depend upon the amount of work done each year; that is, the number of days or hours it is used. This varies on different farms, according to size, type, and system followed, as noted under "Life of the tractor" (p. 11), the average for tractors in Illinois being 45 days per year.

While at first glance this may appear low, when it is remembered that on farms where horses do all the work they are used on an average of only about 100 days annually, it will be seen that where both horses and tractor are used, even though the number of horses is somewhat reduced, the machine need not be expected to have employment for as many days annually as did the horses. The horses kept will still do some of the work, which will, of course, decrease the amount to be done by the tractor. A considerable percentage of the 100 days' work done by horses represents odd jobs for which the tractor can not be used to advantage. Even if the machine were to do all the work formerly done by the horses, it would not normally be employed 100 days per year, inasmuch as it does the work more rapidly.

It should be borne in mind that practically all farm operations must be carried on within limited periods, and that between these seasons there will often be no field work which the tractor can do, either on the home farm or for neighbors. The fact that weather and soil conditions are such as to permit field work with a tractor does not necessarily mean that there is such work to be done. Farm management plays an important part in organizing the farm so as to provide profitable employment for the tractor during as many days as possible. Such organization involves the planning of a crop rotation which will furnish a large amount of work which it can do, the elim-

ination of as many horses as desirable, and the distribution of the work over a long period. However, the rotation should include only such crops as can be grown profitably in that particular section.

The significance of the fact that a large percentage of these Illinois farmers enlarge their farms after buying tractors is readily apparent when the tractor's place in farm management is thus considered. Obviously these men have learned through experience that much more land per man can be handled when a tractor is used than with horses only, and that to get the most out of their investment they must farm land enough to keep their tractors busy at profitable work throughout as much as possible of the available working season.

REPAIRS.

Any figures on the expense of keeping a tractor in repair are of necessity very general. The amount of repairs required depends upon a great many factors, the most influential being the proficiency of the operator and the care he gives the outfit, both when in use and when idle. The conditions under which the outfit is used, that is, whether on rough ground, in dusty fields, etc., the load it is required to pull, and, of course, the quality of the machine itself, all have an effect on the repair bills. Many tractors are kept in repair by the manufacturer during the first year's service, excepting for such items as are caused by some fault of the operator. It is not until the second year, therefore, that the owner bears the full expense.

Of 140 tractor owners in Illinois who had used their outfits one season or less (average age 9 months), 48 reported that they had spent nothing for repairs. The others had repair bills varying from a few cents to a hundred dollars or more, the average being \$22, making the average repairs for the entire group about \$15. Comparatively few machines go through their second season without repair charges. The average repairs for 158 Illinois outfits between the ages of 13 and 24 months (average age 20 months) was \$39. For 34 machines between the ages of 25 and 36 months (average age 32 months), the average repairs amounted to \$79.

The statement is frequently made that a tractor should last indefinitely with proper repairs, since all parts are renewable and the substitution of new parts for worn ones will make the outfit as good as new. The same arguments are often advanced with regard to automobiles, but everyone knows that it doesn't hold true in that case, nor does it with the tractor. In both cases, as with practically all other machines, there comes a time when so many parts have become worn and need replacing that the cost of repairs is so great as to make it unwise to spend such an amount on an old machine, it being more profitable to discard it and buy a new one. Furthermore, it becomes

increasingly difficult to obtain repair parts for any machine as years go by. Not infrequently a manufacturer goes out of business or discontinues the production of a particular machine, thus making it impossible, or at least very expensive, to obtain extra parts. It seldom pays to attempt to use badly worn machines where the farming system provides work for the labor and equipment during most of the working season, since such outfits may cause serious delays and a direct or indirect money loss equal to the cost of a new machine. This is especially true of the tractor.

It is impossible at present to state definitely just what effect the size of tractor has upon the repair bills. The figures thus far obtained would seem to indicate that the percentage of the first cost required annually for repairs is somewhat lower for the 4-plow size than for the smaller outfits, but this may be due to the fact that there are more cheaply constructed and low-priced outfits among the smaller sizes than among the 4-plow machines. It is impossible as yet to make any definite statement as to the annual repairs required by high-priced machines as compared with lower-priced ones of the same capacity. The figures seem to indicate that repairs are somewhat lower for the high-priced machines, but there is not enough difference to justify a positive statement to this effect.

The figures given would indicate an annual repair charge during the first three years of a tractor's life of about 3 per cent of the first cost, but this would undoubtedly increase during the latter years of its life, as is the case with most other machines. It would not seem safe to expect the cost of repairs for a tractor to average less than that for other farm machines, which is a little over 4 per cent,¹ and it is not improbable that it will amount to slightly more than this. In figuring the repair costs to be charged against each day of use or acre plowed, the average annual charge has been taken as 4 per cent of the first cost.

WORK DONE PER DAY.

PLOWING.

The number of acres covered per day by a plow drawn by a tractor is usually slightly greater than that covered by the same-sized horse-drawn plow. The acreage covered by two different machines, each pulling the same number of plow bottoms, often varies considerably, because they travel at different speeds, are in different kinds of soil, plowing different lengths of furrows, etc. Theoretically a 14-inch plow when drawn by a tractor should cover approximately 3 acres in an ordinary working day of 10 hours, as the average plowing speed is slightly more than 2 miles per hour. This will hold true in

¹ U. S. Department of Agriculture Bulletin 338.

actual practice when the plowing conditions are favorable, provided the outfit does not give trouble. That is, a 2-plow machine should plow 6 acres and a 10-plow outfit 30 acres per day, provided both travel at the average rate of speed and are kept moving. However, where trash is to be turned under which frequently clogs the plows, each plow drawn by a large tractor will cover much less ground in a day than one drawn by a small outfit, since the delays will naturally be in proportion to the number of plows pulled. A delay on account of one plow on a 2-plow outfit stops only 1 other plow, while on a 10-plow rig, for example, it stops 9 other plows. To illustrate: Supposing a man operating a 2-plow tractor were compelled to stop 10 times during a day for each plow in order to clear it of trash, and spent three minutes each time (which would not be unusual), the loss of time during the day would amount to a half hour for each plow or but one hour total loss. Each plow would have done nearly as much work as in plowing continuously. On the other hand, a man operating a 10-plow tractor under the same conditions would have to clear each plow the same number of times in proportion to the acreage covered, resulting in a total loss of three or four hours during the day. In such case each plow would have done much less work than under favorable conditions.

In view of these facts it is apparent that when plowing under unfavorable conditions large gang plows do not cover as much ground per day per plow as the smaller ones. However, one man accomplishes considerably more work with the large outfits, even under such conditions.

According to the figures furnished by tractor owners in Illinois the area covered per day (10 net working hours) in plowing with the tractors most commonly used is $6\frac{1}{2}$, $8\frac{3}{4}$, and 10 acres for the 2-, 3-, and 4-plow outfits, respectively. These figures for the 2-plow and 4-plow outfits correspond quite closely with the averages shown in Farmers' Bulletin 719 for the same sizes of tractor, while the average acreage covered by the 3-plow rigs shows an increase of one-half acre per day. This is doubtless due to the placing on the market of a large number of 3-plow outfits of slightly greater power, and therefore larger capacity per day, than the 3-plow machines in use when the data for Farmers' Bulletin 719 were obtained.

In this connection it should be noted that many tractor owners require their outfits to pull one more plow than they are rated to handle. Under such a load the outfit does not cover as much ground as would be covered by a machine built to pull that number of plows. Three plows behind a 2-plow tractor will cover only a little more ground, as a rule, than will the 2 plows, because the tractor usually will travel a little slower, partly because the motor is overloaded and does not maintain its proper speed, and partly because the drive

wheels will slip more than usual with a load heavier than the machine was designed to pull. As a consequence delays on account of small holes or slight grades will be more common, as will also mechanical difficulties.

The reports of a number of men who were thus overloading their machines were tabulated and compared with the results obtained by other men who owned the same make and size of tractor, but who were requiring their machines to pull only their normal loads. This comparison showed that the repairs on the overloaded tractors were considerably higher, more time was lost per day with these outfits, and the estimated life of the overloaded tractors was considerably less than for the machines pulling normal loads. At the same time the increase in ground plowed amounted to only about $1\frac{1}{2}$ acres per day; that is, the additional plow covered about one-half as much ground in a day as did each of the two plows which constituted a normal load. The gasoline consumption per acre averaged somewhat lower for the overloaded machines, as would naturally be expected, since the tractor would not have to travel so far to plow an acre. However, the depth plowed was not so great, and it is reasonable to suppose that the plowing conditions were generally favorable or the third plow would not have been tried. The increased acreage per day and the slight saving in fuel together would not offset the increased repairs and the value of the time wasted from trouble with the outfit. Overloading a tractor is inexcusable save in exceptional cases where speed in completing a job is of the utmost importance. If such speed is required regularly the work could be done more cheaply and satisfactorily with a larger outfit.

OTHER WORK.

The acreage covered per day at field operations other than plowing will vary, of course, with the width of the implement pulled, and this in turn will depend upon the relative draft. It is therefore impossible to give for such operations average figures which would be of value. In harrowing or disking, for example, the width of the implement pulled will depend upon the adjustment of the disks or harrow teeth and the depth of the ground being worked. It is perhaps unnecessary to state that the nature of the soil will also have an influence. The speed of the tractor ordinarily will not be quite as great in soft ground as where the machine has a firm footing, because of the greater slippage of the wheels. On the whole, not so much time is lost on account of clogging or other obstructions when harrowing, disking, etc., as when plowing.

The approximate acreage covered in a day of 10 hours with implements of different widths can be determined easily by allowing about 2 acres per day for each foot of the implement's width where the

outfit is working on soft ground. Where it has a good footing it may be safe to allow $2\frac{1}{2}$ acres for each foot of the implement's width. The acreage covered, of course, will vary with different machines, owing to the different speeds, but the figures given are based on a speed of 2 miles per hour, with an allowance for time lost in turning and the slight overlapping which occurs to a slightly greater extent in most other field operations than in plowing.

By far the largest proportion of the work done by tractors is in plowing and preparing the seed bed and in belt work. While they are used for a number of odd jobs at different times, these represent an insignificant portion of the total work. Hauling, which usually occupies farm horses for several days annually, is not commonly undertaken with the tractor, and in most cases where it has been tried it has been found less satisfactory and more expensive than horses. To make an economical load for the tractor it is necessary to have several heavily loaded wagons, and this makes an unwieldy outfit in turning corners and in getting in and out of loading and unloading places in most towns and villages. Other objections to the use of the tractor for hauling advanced by men who have tried it are the heavy wear and tear on both tractor and wagons on hard roads, expense on the unloaded return trip almost as great as when loaded, and difficulty in handling heavy loads on grades. It is not surprising, therefore, that only about 20 per cent of tractor owners report doing hauling with their outfits and that on the whole it represents less than 4 per cent of the work done by the tractor.

COST OF OPERATING.

Probably the one point in which the prospective purchaser of a tractor will be more interested than in any other will be the cost of performing farm operations with the tractor. This cost is made up of four main factors, namely, *operating expenses* (including fuel, oil, and grease), *repairs*, *depreciation*, and *cost of man labor*. In addition there will be some less important charges, such as interest on the investment, cost of housing, time spent in caring for the outfit other than repair work, etc.

When calculating cost of tractor work the mistake should not be made of omitting any of the first four items, as each of them will amount to considerable per unit of work. The others may be comparatively insignificant in some cases, although they must be included to obtain a strictly accurate figure.

In order to give the prospective purchaser an idea of the average cost of using a tractor, the following figures for the sizes most commonly used have been compiled. From the facts given it is believed that a farmer can approximate the costs for any other size in which he may be interested.

FUEL COST.

The average quantity of fuel consumed per acre in plowing for all tractors on Illinois farms reporting is $2\frac{1}{2}$ gallons. This figure does not vary materially for the different-sized outfits, so long as each pulls its normal load. It is possible, however, to reduce the fuel consumption somewhat by overloading the tractor; that is, adding one more plow bottom than the machine is intended to pull. This, as pointed out already, reduces the distance the machine must travel to plow an acre, and, consequently, results in a slight saving of fuel. The saving is not in proportion to the actual distance traveled, however, since with the overload there is much more slippage of the wheels and consequent loss of power.

There is some slight difference in the fuel consumption between different makes of machines, and also usually a slightly lower consumption in some makes of tractors where gasoline is used instead of kerosene. These differences, however, do not usually amount to a great deal, and for most purposes the figure of $2\frac{1}{2}$ gallons of either gasoline or kerosene per acre of plowing will be as nearly accurate as any that can be used for an average.

The investigation shows that less difficulty is being encountered by owners of kerosene tractors in burning the lower grade of fuel than was indicated in 1916. Slightly more than 50 per cent of the tractors on the Illinois farms reporting are operating on kerosene, and where the machines have been especially designed to burn this fuel the results are apparently very satisfactory, particularly in view of the present price of kerosene as compared with gasoline, the former costing only about one-half as much as gasoline. However, the greater ease in operating on gasoline, and the somewhat greater certainty of steady operation, are sufficient to cause many men to prefer this fuel to kerosene. The fuel consumption, of course, varies considerably, even with the same make of machine and under practically the same conditions, when driven by different operators, as a proficient operator will be able to make such adjustments as will reduce the fuel consumption to the minimum, whereas an inefficient operator will frequently run the outfit in such a manner as to increase unduly the amount of fuel used.

In this case, as in others, a prospective purchaser is not safe in assuming that he can obtain better results than the average, although of course he should endeavor to do so. In making calculations it is always best to be on the safe side. The average price paid for gasoline by the Illinois tractor owners in 1917 was about 20 cents per gallon, and for kerosene slightly less than 10 cents per gallon. With these prices, therefore, the fuel cost per acre for plowing with the tractor averaged about 25 cents where kerosene was used and 50

cents where gasoline was used, not making any allowance for warming up the kerosene engine with gasoline. All kerosene tractors start and warm up on gasoline, but the quantity used for this purpose varies greatly with different makes and with different operators. The quantity of gasoline required for this purpose is in most cases less than 1 gallon per day, and the extra cost for gasoline will usually not exceed 10 cents per day, and should seldom be more than 1 cent per acre plowed.

LUBRICATING OILS.

The quantity of lubricating oil used per acre with different outfits showed a much greater variation than the fuel required. Some men reported using nearly a gallon of lubricating oil per acre, while many reported less than 1 pint per acre. The quantity used will, of course, vary somewhat with the different makes of machines, but the greatest variation will be due to the idea of the operator as to the quantity with which the engine should be supplied.

It is usually false economy to cut the quantity of oil down too low, but on the other hand it is easy to use more than is necessary and than will really be of benefit. The average quantity of oil per acre used in plowing, for all tractors reported from Illinois, was about three-fifths of a quart. With oil at 35 cents per gallon (the average price paid for it), this would amount to $5\frac{1}{4}$ cents per acre. The kind of fuel used does not seem to make any decided difference in the quantity of lubricating oil required.

GREASE.

The quantity of grease, or "hard oil," used also varies widely with different machines and different operators. No attempt to obtain definite figures on this point was made, as it is of such minor importance that few farmers pay much attention to the quantity used. It is not believed that the consumption will amount to 1 pound per day on the average, and the cost is usually in the neighborhood of 10 cents per pound, thus making the cost of this item amount in most cases to less than 2 cents per acre. At any rate, 2 cents per acre would be a reasonable figure.

TOTAL FOR FUEL AND OIL.

Based on the figures given above for the Illinois farms reporting, the average cost per acre plowed for gasoline, oil, and grease is about $57\frac{1}{4}$ cents where gasoline is used, and $32\frac{1}{4}$ cents where kerosene is used.

REPAIRS.

Using the figures given under "Repairs" on page 14, and under "Days Used Annually" on page 12, i. e., the average annual repair charge as 4 per cent of the first cost, and the days used annually as

45, the average repair charge per day for the 2-, 3-, and 4-plow outfits of average price would be 71 cents, 98 cents, and \$1.24 per day, respectively. For the average acreage covered with these different-sized rigs, the repair charge per acre would therefore be 11, 11, and 12 cents, respectively.

DEPRECIATION.

Assuming the average life of a tractor to be $7\frac{1}{2}$ years (see p. 12), the average annual depreciation on the 2-, 3-, and 4-plow outfits will be \$106.67, \$146.67, and \$186.67, respectively. The daily charge, therefore, based on 45 working days per year (see p. 12), will be \$2.37, \$3.26, and \$4.15, respectively.

The depreciation cost per acre, based on the average acreage plowed by the different-sized outfits, as shown on page 15, will be 36 cents, 37 cents, and 42 cents, respectively. From these figures it will be seen that the depreciation charge is one of the largest items which go to make up the total cost of performing work with the tractor, yet it is one which many people ignore entirely when figuring tractor costs. In this case, too, a rather long life has been used, which makes the depreciation somewhat lower than would be altogether safe to count upon. (See p. 12.)

The cause of the depreciation cost for the 4-plow machines being so much higher per acre than that for the smaller rigs is that the 4-plow machines in use up to the present time have cost more in proportion to relative working capacity than in the 2-plow and 3-plow rigs, owing partly to the fact that the smaller sizes have been manufactured in larger quantities, thus reducing the cost of production, and partly to the fact, stated elsewhere, that fewer low-priced machines have been produced in the 4-plow size. This difference undoubtedly will decrease with increased production of the 4-plow outfits.

MAN LABOR.

Comparatively few of the Illinois tractor owners reporting hire operators, and in cases where the machine is operated by hired help the wages paid vary widely. Some men intrust their machines to ordinary hired hands at comparatively low wages, while others attempt to secure first-class operators and are willing to pay fairly high wages to secure thoroughly competent men.

The cost per acre for man labor will be considerably affected, of course, by the wages paid, although in many cases a high-priced operator may do enough more work per day partly to offset his higher wages, and by reducing operating and repair charges may much more than offset them. The greater reliability of the higher-priced operator and the consequent certainty of having the work done when desired also has a value, but this can not be calculated.

To ascertain the cost per acre for man labor in plowing with a tractor, in order to round out these cost figures, the cost for man labor has been placed at \$3 per day. This is about the actual cost for operators to many corn-belt farmers when cost of board, etc., is included. Using this figure, the cost per acre for man labor with the 2-, 3-, and 4-plow outfits, based on the average acreage given, would be 46 cents, 34 cents, and 30 cents, respectively.

INTEREST.

The interest charge on a tractor is a fixed annual charge, and the interest cost per unit of work obviously will vary with the number of days the tractor is used, decreasing as the number of days used increases. Figuring interest at 6 per cent on the average investment (one-half the first cost) for the different-sized tractors, as shown on page 10, and assuming the average number of days used annually to be 45 (see p. 12), the average interest charge per day for the 2-, 3-, and 4-plow outfits will be 53, 73, and 93 cents, respectively.

The interest cost per acre, based on the average acreage covered by the different-sized rigs, would therefore be 8, 8, and 9 cents, respectively. The fact that the acreage covered per day by the 4-plow outfit does not increase in proportion to its cost makes the interest charge per acre for this size higher than for either the 2-plow or 3-plow tractor. The increased acreage plowed per day by the 3-plow rig as compared with the 2-plow offsets the increased interest charge due to higher price. It should be borne in mind, however, that the number of days used annually will cause a variation in the interest charge per unit of work.

TOTAL COST PER ACRE.

PLOWING.

The approximate total cost for plowing an acre with a tractor under normal pre-war conditions, as calculated from the figures given in the preceding pages, would be as shown in Table I.

TABLE I.—*Approximate cost of plowing an acre with 2-, 3-, and 4-plow tractors, based on average cost of \$800, \$1,100, and \$1,400, respectively, and a life of 7½ years of 45 working days per year.*

Size of tractor.	Total, ^a		Fuel.		Oil.	Grease.	Re- pairs.	De- precia- tion.	Man labor.	Inter- est.
	Gasoline tractor.	Kerosene tractor.	Gasoline.	Kerosene.						
2-plow.....	\$1.58½	\$1.33½	\$0.50	\$0.25	\$0.05½	\$0.02	\$0.11	\$0.36	\$0.46	\$0.08
3-plow.....	1.4½	1.22½	.50	.25	.05½	.02	.11	.37	.34	.08
4-plow.....	1.50½	1.25½	.50	.25	.05½	.02	.12	.42	.30	.09

^a The cost of housing the outfit and other minor overhead charges, such as taxes, insurance, etc., are not included.

OTHER OPERATIONS.

From the figures given above it will be a comparatively easy matter to arrive at relative costs for other operations with the tractor. For all field operations the daily charges for interest, depreciation, and man labor will, of course, be about the same, but must be divided by the acreage covered by the implement used. This acreage will vary with different implements. The fuel and oil charge will be the same for a 10-hour day in other field operations as in plowing, provided the tractor is loaded to the same extent. This, however, is frequently not the case. If a comparatively light load is drawn, the fuel and oil consumption will be somewhat reduced, but not in proportion to the load. For stationary work, if the engine is working to full capacity, the fuel and oil charges will be approximately the same as for a day's work in plowing, but no grease will be used on most machines. This, however, would be only a small item.

ECONOMY.

From the figures given under the cost of operation, it will be noted that the cost of doing plowing or other field operations with a tractor is approximately the same as with horses excepting for the item of man labor. This will average lower with the tractor than where horses are used, assuming wages to be the same in each case.

The advantage of the tractor, therefore, like that of most other improved farm machines, lies not so much in the reduction of the cost of performing a unit of work as in the fact that it permits one man to do considerably more work within a given period of time. This has been true of practically all improved farm machines, even of the grain binder, which is generally considered as one of the greatest agricultural inventions of the century, which did not, contrary, perhaps, to general opinion, decrease the cost of harvesting wheat to any considerable extent, but did increase about eightfold the acreage which one man could handle. (See Department of Agriculture Bulletin No. 627.)

Men who hope to reduce greatly the cost of farming operations by the purchase of a tractor should bear these facts in mind, and also the fact that few tractor owners mention as an advantage reduction in the cost of performing farm work. Judging by the experience of tractor users, it is not safe to expect any material reduction in the cost of farm operations per acre through the use of the tractor, but it is safe to expect to be able to increase the crop acreage to a very considerable extent, and, at the same time, the amount of crops which one man can raise.

Furthermore, it should be remembered that the cost of doing the work with a tractor as above outlined in most cases can not be

directly compared with the cost of doing it with horses, since on farms where tractors are used a number of horses generally are retained, and any comparison, therefore, must be made between the cost of operating the farm with horses alone and the cost of operating with the tractor and a certain number of horses. Not infrequently horses stand idle while the tractor is being used for field work because there is not sufficient help available to use them at the same time, and in such cases part of the cost of their maintenance must be considered when figuring the cost of farm operations, since they are as much a part of the farm power plant as is the tractor.

Neither should it be forgotten that not only should the relative expense of operation with the two methods be considered, but also the relative results. The increased crop acreage and consequent increase in incomes which the purchase of the tractor will often make possible may much more than offset a slight increase in the operating expenses of the farm.

QUALITY OF WORK.

Not a few farmers when considering the purchase of a tractor hesitate because of the fear that they may not be able to do the work as satisfactorily as with horses. This applies principally to plowing. That there is little reason for this attitude is indicated by the fact that more than 50 per cent of tractor owners report that the quality of work done by the tractor is better than that done by horses, while less than 3 per cent say it is poorer.

The quality of work done in plowing does not depend so much upon the tractor as upon the plow and its adjustment. Under average conditions, the work done by most engine gang plows when properly adjusted is fully equal, and often superior, to the work done by either a walking or gang plow drawn by horses and operated by a skillful plowman. If a job of plowing where a tractor is used is not satisfactory, it is not usually the fault of the tractor but of the plow, or, more probably, it is due to misadjustment of the plows. Of course, in fields with obstructions, sharp angles, etc., the tractor may be responsible for poor work because of its clumsiness, but under most conditions the plows and the operator determine the quality of the work done. The tractor's part is to furnish the power to pull the plows.

This point should be kept in mind by farmers who select their tractors by visiting demonstrations of different makes of outfits. The quality of the work done by different machines should be of value in selecting a good *gang plow*, but it is practically worthless in determining the value of the different tractors. It is quite possible that a tractor of very inferior quality may be pulling a good gang plow, well adjusted, and doing much better work than an outfit

of first-class quality which is pulling a poor plow or one that is out of adjustment.

The average depth of plowing done with tractors by the Illinois farmers who furnished data for this bulletin, is slightly less than 7 inches. The average depth they had previously plowed with horses was about $5\frac{1}{2}$ inches. While this deeper plowing is ordinarily considered as indicating a better quality of work, it does not appear to have had any marked effect on the crop yields.

As to the quality of disking, or other work on plowed land, it will, of course, as with plowing, depend largely upon the implement drawn and the skill of the operator. The question of packing the soil is usually more important in connection with work on plowed land than in plowing, but that this is not a serious drawback with modern tractors in Illinois is indicated by the fact that 86 per cent of Illinois tractor owners reporting say that their tractors are satisfactory for use on plowed land.

OPERATION.

In view of the fact that difficulty in operation is mentioned by tractor owners as the principal disadvantage of the tractor, it seems pertinent to state that though any man of ordinary ability can operate and care for a gas tractor very satisfactorily after a little study and experience, it is decidedly unwise for him to undertake to gain the necessary experience by experimenting with his own machine. In most cases he can obtain the experience more cheaply elsewhere. Experience in running stationary engines or automobiles, while of some value, is not enough. The mere starting of the motor, changing of gears, and stopping, are simple matters, and any farmer can quickly learn to do these, but the important thing is the ability to detect trouble the minute it begins to develop and to be able to remedy it promptly instead of allowing it to run along until an expensive delay results.

A great many owners report that it is extremely difficult to get hired help capable of operating a tractor satisfactorily. Where a tractor is to be operated by hired help it is very important for the owner to understand the proper care of the outfit in order to see that it is not abused.

The fact that a tractor does demand a certain amount of knowledge on the part of the operator can scarcely be considered a disadvantage. The necessary training usually can be obtained rather easily without great expense. It pays to spend a few days in gaining experience under a competent instructor, and it is unwise to attempt to run a tractor without such preparation. One farmer writes: "I had no experience with the tractor when I started and would have made \$500 more during the season if I had had the same

experience when I started in the spring as I had in the fall when I quit."

With the increasing use of tractors, as well as of automobiles and stationary engines, farmers are rapidly becoming familiar with the care and operation of gas engines. At the same time tractors are being improved and simplified so that difficulties in operation are growing less each year. One generation of well-trained and competent operators will disseminate information so that future generations will acquire knowledge on the subject as unconsciously, yet as thoroughly, as the average farmer's son acquires his knowledge of horses.

The mistake should not be made of assuming that any boy can operate a tractor in an efficient manner; only a proficient operator can handle a tractor properly.

Some tractor manufacturers offer to give purchasers of their machines thorough instruction at a reasonable cost. Purchasers of farm tractors should avail themselves of the opportunities thus offered to obtain a training in the use of the particular machine they will be called upon to operate, which will go far toward insuring their success in its use.

RELIABILITY.

The reliability of a tractor depends to a very great extent upon the ability of the operator. Of more than 300 tractor owners in Illinois 54 per cent reported that their outfits were not disabled a single day when needed during the past season. Of the remaining 46 per cent the average number of days their tractors were out of commission when needed was 5. This average, however, did not include one man who stated that his machine was out of commission about half the time.

The reports of tractor owners indicate that with a careful and proficient operator a gas tractor is a very dependable source of power. Occasional slight delays probably will be encountered, but serious ones will be exceptional, whereas with a careless or incompetent operator expensive delays are apt to be frequent.

Of the tractors owned by Illinois farmers reporting, about 90 per cent are operated by the owner or some member of his family, the best results usually being obtained by this class of operators. Thirty-six per cent of Illinois owners reported no time lost in the field on account of trouble with the outfit. This probably means that the time lost was not worth mentioning. Most men do not consider it trouble so long as they know at once the cause of stoppage or other irregularity in the engine's operation, and are able to remedy it promptly. The average time lost per day by the 64 per cent reporting trouble is a little over three-quarters of an hour.

DISPLACEMENT OF HORSES.

Many men expect the purchase of a tractor to enable them to do away very largely with the use of horses for farm work. Up to the present time, however, the tractor has not displaced horses to the extent commonly expected. Its greatest advantage, as before mentioned, has been in the fact that it does the heavy work quickly and thus completes it within the proper season, since it places at the farmer's command a large amount of untiring power when needed.

The tractor does displace horses to some extent, but only in about three-fourths of the cases where it is used on the same number of acres as were previously farmed. In these instances, the horses displaced average about four, and represent about three-fifths of the cost of the tractor outfit.

It should be noted that the corn belt does not offer the most favorable conditions for the displacement of horses by the tractor, since there is a great deal of work on this type of farm for which the machine can not be used profitably. The work which requires the largest amount of power on the corn-belt farm, contrary to a somewhat general opinion, is not plowing, but cultivating. In figure 1 is shown the distribution of horse labor on a typical corn-belt farm, from which it will be seen that the peak load (that is, the greatest amount of work) comes about the end of May, which is the season when corn cultivating is at its height.

Several makes of the motor-driven cultivators have recently been placed on the market. These may prove valuable auxiliaries to the tractor, particularly under corn-belt conditions. The use of these two machines on corn-belt farms probably would result in a much greater displacement of horses than where the tractor alone is used.

The raising of colts has been for years an industry of considerable importance on farms in the corn belt, and it would seem natural to expect that where tractors were bought and the work stock thus relieved of the heavy field work, the percentage of brood mares kept would be increased, and that the chances of raising more and healthier colts would be enhanced. It was found, however, that on a group of 261 farms in Illinois the brood mares constituted 27 per cent of the work stock before tractors were bought, and while the work stock decreased to some extent after the purchase of the tractor, the percentage of brood mares increased only 6 per cent, making the percentage now kept amount to 33 per cent. This is the same percentage of brood mares kept on a large group of farms in Illinois before using tractors, records of which were included in Farmers' Bulletin 719. The data contained in the bulletin mentioned showed an increase of 3 per cent in the brood mares, making 36 the percentage kept after purchasing tractors.

From these figures it does not appear that the tractor is having any very marked effect upon the percentage of brood mares in the corn belt. Certainly it is not, as a general rule, increasing the number of colts raised on farms where it is used, inasmuch as the total number of

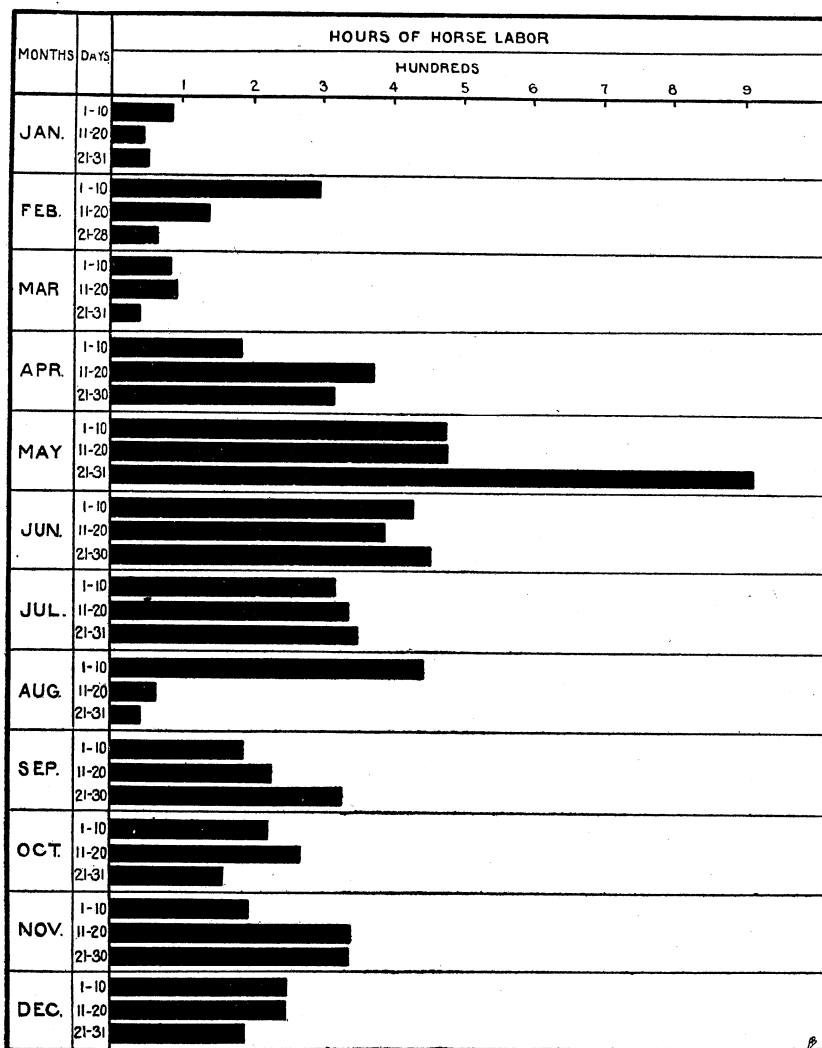


FIG. 1.—Showing distribution of horse labor on a typical corn-belt farm (in Illinois) of 200 acres, with about 120 acres of corn, 45 of oats, and 30 of hay (11 horses).

brood mares on farms where tractors were bought showed a general decrease of 8 per cent.

CUSTOM WORK.

Early in 1916 investigations showed that 45 per cent of Illinois tractor owners reporting used their outfits for custom work to some extent. A great many of them bought their outfits with the idea of

using them for such work, while others procured them for use on their own farms only, and undertook custom work at the request of neighbors or because it seemed to offer an opportunity for the tractor to help pay for itself. The investigations made in the same area in the summer of 1917 showed that this per cent had remained about constant.

The use of a tractor at custom work for field operations seems a rather reliable indication that the home farm is not large enough to utilize a tractor economically. This conclusion is borne out by the fact that the average size of the farms owned by men who use their tractors for custom work is slightly less than for the farms where the tractor is not so used. An efficient farm should be large enough to keep both labor and equipment employed during practically the entire working season. Of course, in the fall, after the work on the home farm is completed, it may be desirable to use the tractor for custom work provided an adequate return can be obtained. This, of course, means that most of the custom work will be stationary operations, such as thrashing, shredding fodder, shelling corn, etc., which can be done after the weather is unfit for field operations.

However, there seems to be some doubt as to whether it pays as a general rule to use the tractor for custom work even under these conditions. Of these Illinois tractor owners who have used their machines for custom work, one-third stated that it had not paid them. It should be noted also that comparatively few farmers consider their entire expenses when calculating the profits from this source. Most of them ignore depreciation charges, and include only fuel, oil, labor, and such repairs as may be required during the time the outfit is used. Under these conditions it not infrequently happens that a tractor owner does custom work at an actual loss, or at any rate at no real profit when all expenses are considered.

On the whole it is preferable that the machine be kept busy on the home farm during as large a percentage of the working season as practicable, so that the owner may derive the maximum profit from its use. Certainly a tractor owner is not justified in neglecting his own work to accept employment on a neighbor's farm at the rates usually paid, although this is not an uncommon occurrence. A little ready cash seems to blind some men to their own best interests and to the ultimate profit which should be made through the use of their machines at their own work. For the 47 per cent of Illinois tractor owners reporting who did custom work in 1917, the average number of days the outfit was used annually for this purpose was 17.

EFFECT OF USE OF TRACTOR ON CROP YIELDS.

The reports of Illinois tractor owners were studied to ascertain what effect the tractor has had on crop yields. The answers to the questions which were asked on this point indicate that although in-

creases are more common than decreases, they are not sufficiently frequent to warrant a farmer in attaching too much importance to this feature when considering the purchase of a tractor. The principal reasons for increases in yields were timeliness in having the work done and deeper and more thorough preparation of the seed bed in hot weather. Conservation of moisture due to the rapidity with which the work could be performed and the carrying on of more than one operation at a time were also mentioned. Decreases were usually credited to the packing of the soil when damp, and occasionally to delay in getting work done because of trouble with the outfit. By far the largest percentage of owners, however, report no noticeable effect in either direction which can be attributed to the tractor.

Although the depth of plowing done with the tractor averages about $1\frac{1}{2}$ inches greater than that done with horses, this seems to have had a rather negligible effect on yields. This is perhaps somewhat contrary to what is generally expected, but is doubtless accounted for by the fact that deep plowing alone does not necessarily increase the yields, other good farming methods and practices being required in connection therewith in order to make it profitable.

TRACTOR EQUIPMENT.

During the past few years, the farm tractor has developed more rapidly than has the field equipment for use with it, with the exception of gang plows. On many farms where tractors are used no special equipment other than plows is bought, other operations for which the tractor is used being performed with the ordinary machines designed for use with horses.

It is obviously impossible to obtain maximum results with a tractor when it is used with implements designed primarily for use with horses, and the objection of many tractor owners that the tractor can not be used with profit for certain types of field work will probably cease to hold good with the development of special machinery for use with the tractor. There is considerable activity at present in the line of inventions of implements and attachments designed especially for use with the tractor. Many of these will doubtless increase its value for farm work, making it practicable and economical for many field operations where its use is now both impracticable and uneconomical. It is for the purpose of doing work of the nature last mentioned that several horses are often kept after the purchase of the tractor. With the development of special machinery as above outlined, it seems probable that a higher percentage of work stock will be displaced where the tractor is used.

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Economic Study of Farm Tractor in Corn Belt. (Farmers' Bulletin 719.)
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